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Computer Program for Predicting Off-Design Performance of Centrifugal Compressors

A computer program has been developed which predicts centrifugal compressor performance through utilization of empirical correlations which are related to the compressor geometry and velocity diagram characteristics. A complete knowledge of the compressor overall geometry and working fluid total inlet conditions is required for the program's use. On a given speed line, compressor performance is calculated for a range of inlet velocity levels. At flow rates between surge and choke, individual efficiency decrements, compressor overall efficiency, and compressor total pressure ratio are tabulated. Working fluid state conditions and flow properties are calculated using a mean streamline one-dimensional analysis. The program is limited to centrifugal compressors with channel diffusers operating up to their choke point.

Centrifugal compressors are conventionally used in refrigeration cycles, refining systems, aircraft auxiliary systems, turboshaft engines, and other systems where lightweight compact compression is required. The off-design performance characteristics of centrifugal compressors are of interest because of the large effects that compressor component performance has on overall cycle performance and because the compressors may operate at off-design conditions much of the time. In addition to good performance at off-design flow rates, it is important that the compressor operate stably over the range of flows and speeds required by the operating system. The usable range of the compressor pressure ratio-mass flow characteristic is bounded by the surge and choke mass flow rates. Operation at flows less than the surge point flow should be avoided because of potentially dangerous vibrations induced by the intermittent flow reversals and power loss. Operation with the compressor choked is generally avoided because of the poor compressor efficiency and pressure ratio at the choke point. The problem undertaken in this computer program is to determine the centrifugal compressor performance characteristics over a range of rotative speeds and flow rates and predict the usable range of flow rates at which the compressor can operate.

Input values of inlet critical velocity ratio are used to determine compressor mass flow rate. Individual losses are calculated using velocity diagram characteristics and empirical correlations determined by the input absolute velocity level and compressor geometry. For compressors having inlet guide vanes, it is assumed that the vanes are placed in a constant-area annulus having no wall curvatures or slopes. Overall compressor efficiency, total pressure ratio, and mass flow rate are tabulated for each operating point inside the predicted range for each speed line that is input.

In the normal mode of operation, the program performs two iterations over the range of inlet absolute critical velocity ratios which are specified. On the first iteration, the compressor choking flow rate is determined. On the second iteration, the printout of compressor performance at flow rates outside the usable range is deleted. A listing of the input information is tabulated for the compressor configuration studied. Then the compressor surge and choke flow rates are printed out. Finally, for each calculated point inside the operating range, compressor equivalent weight flow, total pressure ratio, total efficiency, and individual efficiency decrements are printed out.

Notes:

1. The program is written in FORTRAN IV for use on an IBM 7094 II/7044 direct couple computer.
2. Inquiries concerning this program should be directed to:

   COSMIC
   Information Services
   112 Barrow Hall
   University of Georgia
   Athens, Georgia 30602
   Reference: LEW-12186

Source: Michael R. Galvas
U.S. Army Air Mobility R&D Lab.
(LEW-12186)

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